Instruction manual

General instructions digital Mass Flow instrument LIQUI-FLOW L30

Doc. no.: 9.17.044D Date: 26-07-2011

ATTENTION
Please read this instruction manual carefully before installing and operating the instrument.
Not following the guidelines could result in personal injury and/or damage to the equipment.

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HIGH-TECH

SCOPE OF THIS MANUAL

This manual covers the general part of digital LIQUI-FLOW L30 mass flow instruments for liquids. It treats the general instructions needed for the instruments.
More information can be found in other documents.

Multibus instruments have modular instruction manuals consisting of:

- **General instructions digital LIQUI-FLOW L30 (document nr. 9.17.044)**

- Operation instructions digital instruments (document nr. 9.17.023)

- Fieldbus/interface description:
  - FLOW-BUS Interface (document nr. 9.17.024)
  - PROFIBUS-DP Interface (document nr. 9.17.025)
  - DeviceNet Interface (document nr. 9.17.026)
  - RS232 Interface with FLOW-BUS protocol (document nr. 9.17.027)
  - Modbus interface (9.17.035) special request

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Bronkhorst High-Tech B.V.
July 2011

Warranty

The products of Bronkhorst High-Tech B.V. are warranteed against defects in material and workmanship for a period of three years from the date of shipment, provided they are used in accordance with the ordering specifications and the instructions in this manual and that they are not subjected to abuse, physical damage or contamination.
Products that do not operated properly during this period may be repaired or replaced at no charge. Repairs are normally warranteed for one year or the balance of the original warranty, whichever is the longer.
See also paragraph 9 of the Conditions of Sales.

The warranty includes all initial and latent defects, random failures, and indeterminable internal causes.

It excludes failures and damage caused by the customer, such as contamination, improper electrical hook-up, dropping etc.

Re-conditioning of products primarily returned for warranty service that is partly or wholly judged non-warranty may be charged for.

Bronkhorst High-Tech B.V. prepays outgoing freight charges when any part of the service is performed under warranty, unless otherwise agreed upon beforehand. However, if the product has been returned collect to Bronkhorst High-Tech B.V., these costs are added to the repair invoice. Import and/or export charges, foreign shipping methods/carriers are paid for by the customer.

Short-Form Operation Instruction

Before installing your Mass Flow Meter/Controller it is important to read the attached label and check:
- Flow/pressure rate
- Fluid to be measured
- Up- and downstream pressures
- Input/output signal

Check the red-coloured sticker and make sure the test-pressure is in agreement with normal safety factors for your application.

Check if the piping system is clean. For absolute cleanliness always install filters to assure a clean liquid stream.

Install the LIQUI-FLOW L30 Meter/Controller in the line and tighten the fittings according to the instructions of the supplier of the fittings.
Choose the mounting position according to the directions given in this manual.

Check the system for leaks before applying fluid pressure.

Electrical connections must be made according to the hook-up diagram in the back of this manual.

Short form start-up

Install instrument in your process.
Provide instrument with correct pressure(s).

Connection analog operation

Connect the instrument to the power supply/readout unit with the 9-pin cable at the circular connector.

Connection BUS/digital operation

For this procedure: see description for specific fieldbus.

(General) Operation

Let the instrument warm-up for 30 minutes for best accuracy.

Send a setpoint to the instrument and check the measured output signal.

Your Mass Flow Meter/Controller is now ready for operation.

TABLE OF CONTENTS

1 INTRODUCTION 6
1.1 General description 6
1.1.1 Liquid flow 6
1.1.2 Housing 6
1.1.3 Valves 7
1.2 Sensor principles 7
1.2.1 LIQUI-FLOW L30 sensor 7
1.3 Valve principles 8
1.3.1 Solenoid valve 8
1.3.2 Bellow valve 8
1.4 Liquid conversion factors 9
1.5 Software for physical properties of gases and liquids 9
2 INSTALLATION 10
2.1 Receipt of equipment 10
2.2 Return shipment 10
2.3 Service 10
2.4 Mounting 10
2.5 Fluid/gas connections 10
2.6 Piping 11
2.7 Electrical connections 11
2.8 Pressure testing 11
2.9 Supply pressure 11
2.10 System purging 11
2.11 Seals 11
2.12 Equipment storage 11
2.13 Electromagnetic compatibility 12
2.14 Electro static discharge 12
3 OPERATION 13
3.1 General 13
3.2 Power and warm-up 13
3.3 Start-up 14
3.4 Operating conditions 14
3.5 Instrument performance 14
3.5.1 Meters 14
3.5.2 Controllers 14
3.6 Manual operation 14
3.7 Analog operation 15
3.8 BUS / digital operation 16
4 MAINTENANCE 17
4.1 General 17
4.2 LIQUI-FLOW L30 sensor 17
4.3 Controllers 17
4.4 Control valves 17
4.4.1 Solenoid valves 17
4.4.2 Bellows valve 18
4.5 K_v-value calculation 18
4.6 Calibration procedure 18
5 DIGITAL INSTRUMENT 19
6 INTERFACE DESCRIPTION 19
7 TROUBLESHOOTING 20
7.1 General 20
7.2 Troubleshooting summary general 20

Appendices

1 Enclosures (if applicable)
2 Hook-up diagram
3 Calibration certificate

1 INTRODUCTION

1.1 General description

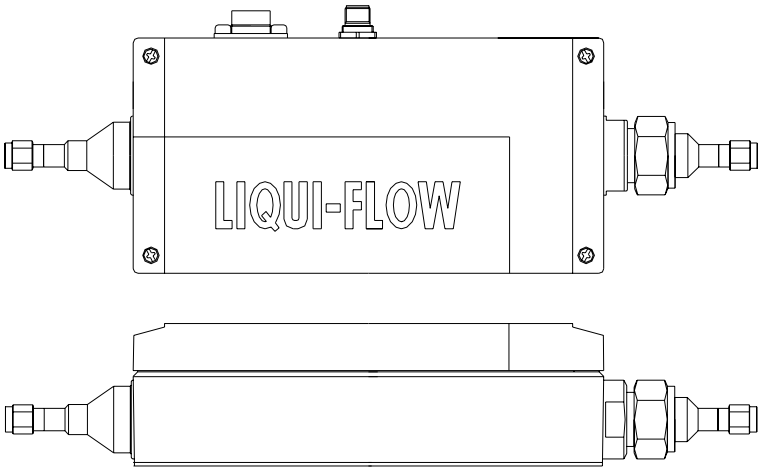
1.1.1 Liquid flow

The Bronkhorst High-Tech B.V. series LIQUI-FLOW L30 meter/controller for liquids is an accurate device for measuring liquid flows from 2 kg/h up to 20 kg/h with pressures up to 400 bar depending on body rating, virtually independent of pressure and temperature changes. The system can be completed with a control valve and flexible readout unit to measure and control liquid flows.

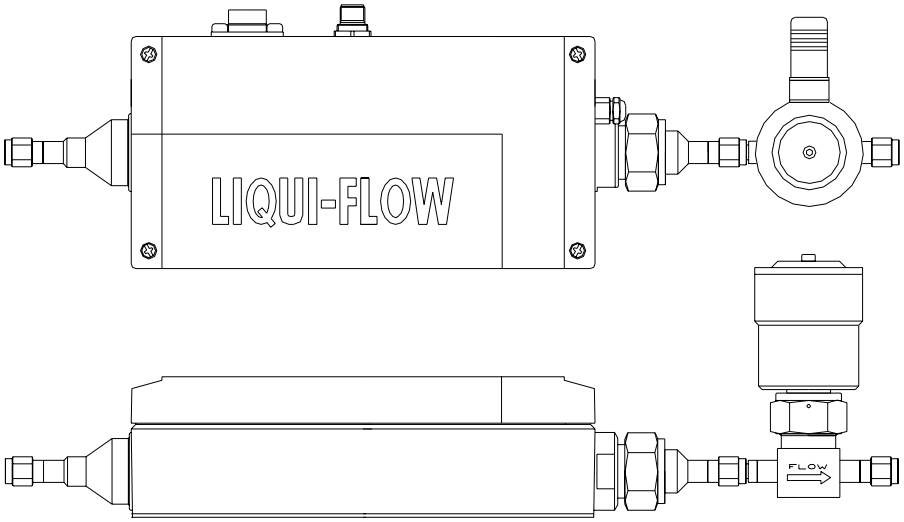
1.1.2 Housing

Each instrument housing style incorporates several provisions to comply with EMC requirements.

Meter housing



Controller housing with C5 valve

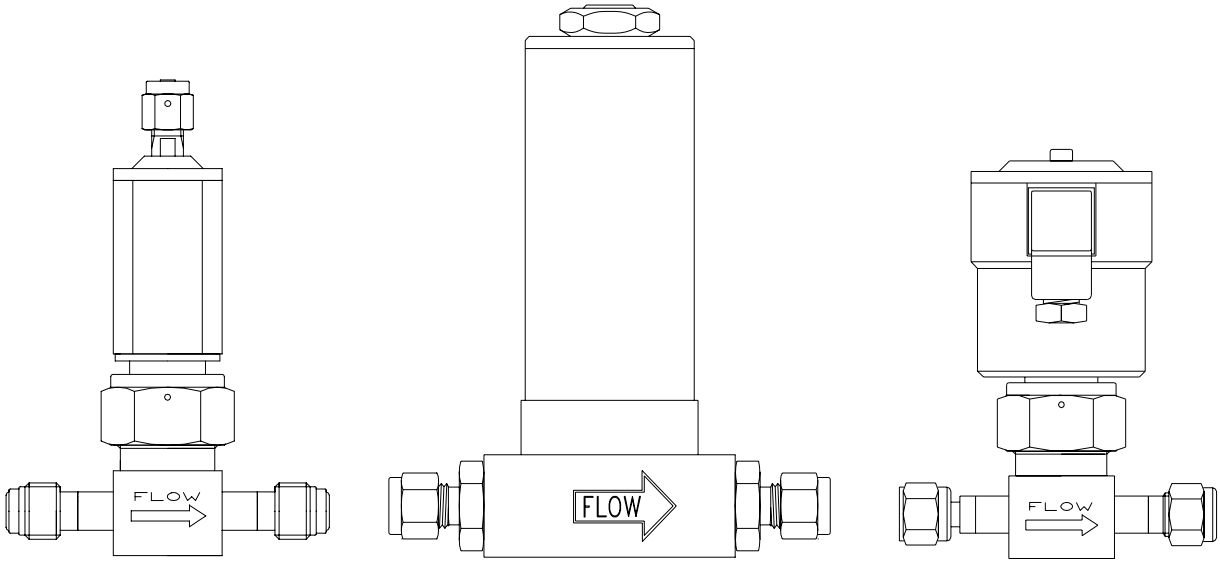


1.1.3 Valves

LIQUI-FLOW L30 controllers are fitted with a modular valve. The valve is attached by means of a port connector.

Valves for liquids

C2 valve	**C4 valve**	**C5 valve**
Direct operating valve for liquids (“open” sleeve) metal sealed with purge connector.	Direct operating valve for gases and liquids. (bellow)	Direct operating valve for liquids (“open” sleeve) metal sealed.
C2 valve = normally closed	C4 valve = Normally closed.	C5 valve = normally closed



1.2 Sensor principles

1.2.1 LIQUI-FLOW L30 sensor

Measuring Principle
The LIQUI-FLOW model for flowrates up to about 20kg/h is basically a straight pipe. On this pipe a configuration of sensors and heaters is placed. The heater temperature is maintained at a certain level above the incoming liquid temperature.
The power needed to maintain this temperature while the fluid is flowing is measured.
Furthermore the output temperature downstream, at a certain distance from the heater is measured, resulting in the delta-T signal (T_{out} -T_{in}).
By combining the two signals, the transfer function of the instrument can e descried according to the following equation:

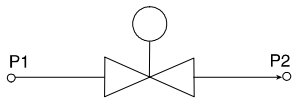
$$V_{signal} = \frac{Power}{\Delta T} K \cdot c_p \cdot \Phi_m$$

V_{signal} = output signal
c_p = specific heat
Φ_m = mass flow

1.3 Valve principles

Control valves are not designed to provide positive shut-off, although some models have excellent capabilities for this purpose.
It is recommended to install a separate shut-off valve in the line if required. Also pressure surges, as may occur during system pressurisation must be avoided. The following models can be distinguished:

1.3.1 Solenoid valve



Flow control valve

This is considered to be the standard (direct operated) control valve. In general it is a normally closed solenoid valve. The plunger is lifted by the force of the magnetic field of the coil. The orifice under the plunger is removable for optimising the orifice diameter. Also a normally opened solenoid valve is available.

1.3.2 Bellow valve

This valve type is a direct driven, low power, solenoid operated control valve. A special design, incorporating a metal bellow allows for a relatively large orifice opening to be controlled. The design is suited for low pressure or vacuum applications.

1.4 Liquid conversion factors

The general formula for determining the relationship between signal and mass flow reads:

$$V_{signal} = k \cdot c_p \cdot \Phi_m$$

in which: V_{signal} = output signal
k = calibration constant
c_p = heat capacity at constant pressure of the fluid
Φ_m = mass flow

A conversion factor must be used if the liquid flow meter is not used on the calibrated liquid.
This conversion factor reads:

$$\Phi_{m_2} = Cf \cdot \Phi_{m_1} \qquad Cf = \frac{c_{p1}}{c_{p2}}$$

in which: c_{p1} = heat capacity of the calibration liquid
c_{p2} = heat capacity of the new liquid

For application of this formula consult Bronkhorst High-Tech B.V.

1.5 Software for physical properties of gases and liquids.

Bronkhorst High-Tech B.V. gathered the physical properties of over 600 fluids in a database called FLUIDAT®.
Application software, such as FLUIDAT® on the Net (FOTN), enable the user to calculate accurate conversion factors, not only at 20°C/1 atm, but at any temperature/pressure combination.
Apply to your distributor for more details of this software.

2 INSTALLATION

2.1 Receipt of equipment

Check the outside packing box for damage incurred during shipment. Should the packing box be damaged, then the local carrier must be notified at once regarding his liability, if so required. At the same time a report should be submitted to:

BRONKHORST HIGH-TECH B.V.
RUURLO HOLLAND

If applicable, otherwise contact your distributor.
Remove the envelope containing the packing list; carefully remove the equipment from the packing box.
Do not discard spare or replacement parts with the packing material and inspect the contents for damaged or missing parts.

2.2 Return shipment

When returning material, always describe the problem and if possible the work to be done, in a covering letter.

It is absolutely required to notify the factory if toxic or dangerous fluids have been metered with the instrument!

This to enable the factory to take sufficient precautionary measures to safe-guard the staff in their repair department. Take proper care of packaging. If possible use the original packing box. Seal instrument in plastic etc.

Contaminated instruments must be dispatched with a completely filled in 'declaration on contamination form'.
Contaminated instruments without this declaration will not be accepted.

Note:
If the instruments have been used with toxic or dangerous fluids the customer should pre-clean the instrument.

Important:
Clearly note, on top of the package, the customer clearance number of Bronkhorst High-Tech B.V., namely:

NL801989978B01

If applicable, otherwise contact your distributor for local arrangements.

2.3 Service

If the equipment is not properly serviced, serious personal injury and/or damage to the equipment could be the result. It is therefore important that servicing is performed by trained and qualified service personnel. Bronkhorst High-Tech B.V. has a trained staff of servicemen available.

2.4 Mounting

Install the LIQUI-FLOW in accordance to the direction of the FLOW arrow. The arrow for flow direction is indicated on the instrument, between process fittings.

2.5 Fluid/gas connections

Bronkhorst High-Tech B.V. LIQUI-FLOW meters/controllers are equipped with compression or face-seal-fittings. For LIQUI-FLOW these fittings are orbitally welded to the body. For leak tight installation of compression type fittings be sure that the tube is inserted to the shoulder in the fitting body and that no dirt or dust is present on tube, ferrules or fittings. Tighten the nut finger-tight; while holding the instrument, then tighten the nut 1 turn.
If applicable follow the guidelines of the supplier of the fittings. Special types of fittings are available on request.

*** Note:** Always check your system for leaks, before applying fluid/gas pressure. Especially if toxic, explosive or other dangerous fluids are used.

2.6 Piping

BE SURE THAT PIPING IS ABSOLUTELY CLEAN!
DO NOT install small diameter piping on high flowrates, because the inlet jet-flow will affect the accuracy.
DO NOT mount abrupt angles direct on in- and outlet, especially not with high flowrates. We recommend at least 20 pipe diameters distance between the angle and the instrument.
Special care should be taken in regard to reducers placed just in front of the LIQUI-FLOW. High pressure drop and flow disturbance can occur which can influence the LIQUI-FLOW.

2.7 Electrical connections

Bronkhorst High-Tech B.V. recommends using their standard cables. These cables have the right connectors and if loose ends are used, these will be marked to prevent wrong connection.

2.8 Pressure testing

Each LIQUI-FLOW is pressure tested to at least 1.5 times the working pressure of the process conditions stipulated by the customer, with a minimum of 8 bar.
The tested pressure is stated on the flow meter/controller with a RED COLOURED sticker. Check test pressure before installing in the line.
If the sticker is **not** available or the test pressure is incorrect, the instrument should **not** be mounted in the process line and be returned to the factory.
Each instrument is helium leak tested to at least $2 \cdot 10^{-9}$ mbar l/s Helium.

2.9 Supply pressure

Do not apply pressure until electrical connections are made. When applying pressure to the system, take care to avoid pressure shocks in the system and increase pressure gradually, especially on high pressure units incorporating a piston operated control valve.
Make sure in case of a controller that the used valve can withstand the system pressure.

2.10 System purging

If explosive gases are to be used, purge the process with inert dry gas like Nitrogen, Argon etc. for at least 30 minutes at a high enough flow.
In systems with corrosive or reactive fluids, purging with an inert gas is absolutely necessary, because if the tubing has been exposed to air, introducing these fluids will tend to clog up or corrode the system due to a chemical reaction with oxygen or moist air.
Complete purging is also required to remove such fluids from the system before exposing the system to air. It is preferred not to expose the system to air, when working with these corrosive fluids.

2.11 Seals

Bronkhorst High-Tech B.V. has gathered a material compatibility chart from a number of sources believed to be reliable.
However, it is a general guide only. Operating conditions may substantially change the accuracy of this guide. Therefore there is no liability for damages accruing from the use of this guide.
The customer's application will demand its own specific design or test evaluation for optimum reliability.
So check if the seals like O-rings, plunger and packing gland of the capillary are correct for the process.

2.12 Equipment storage

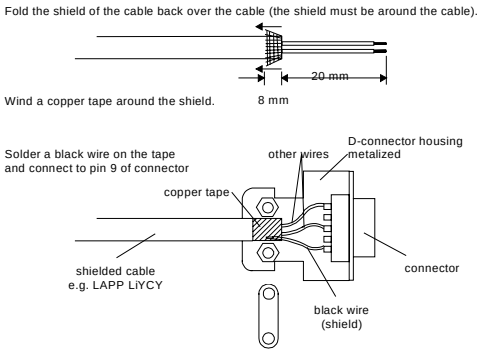
The equipment should be stored in its original packing in a cupboard warehouse or similar. Care should be taken not to subject the equipment to excessive temperatures or humidity.

2.13 Electromagnetic compatibility

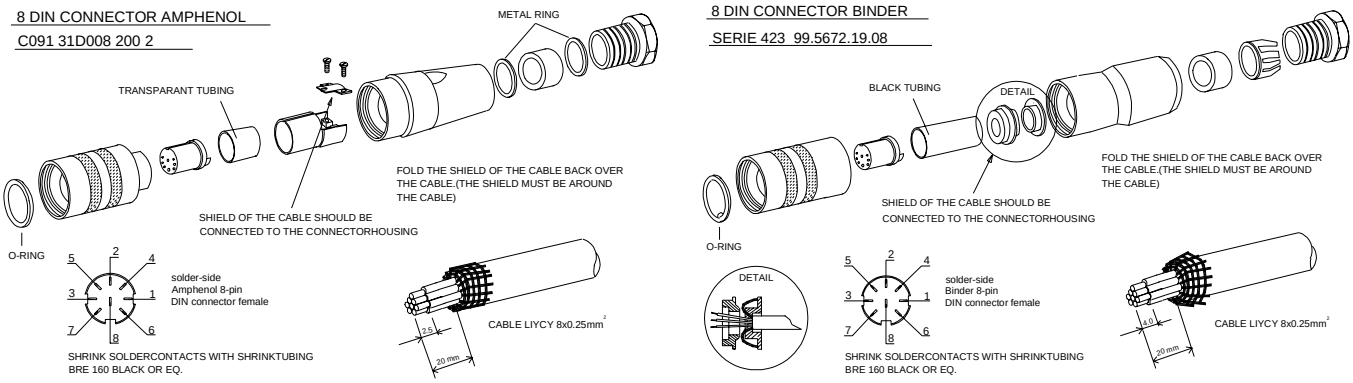
Conditions for compliance with EMC requirements

All instruments described in this manual carry the CE-mark.
Therefore they have to comply with the EMC requirements, as they are valid for these instruments.
However compliance with the EMC requirements is not possible without the use of proper cables and connector/gland assemblies.
For good results Bronkhorst High-Tech B.V. can provide standard cables. Otherwise follow the guidelines as stated below.

1. D-Connector assembly



2. Connector LIQUI-FLOW



Note:
When connecting the system to other devices (e.g. to PLC), be sure that the integrity of the shielding is not affected. Do not use unshielded wire terminals.

1. For FLOW-BUS S(F)TP data (patch) cable connection to M12 connectors follow the instructions of the supplier. It is important to use shielded twisted pair cables and shielded RJ45 modular jack connectors.

2. For PROFIBUS-DP, Modbus or DeviceNet data cable connections follow the instructions of the cable suppliers for the specific field-bus system.

2.14 Electro static discharge

This instrument contains electronic components that are susceptible to damage by static electric discharges. Proper handling procedures must be taken during installation, removing and connecting the electronics.

3 OPERATION

3.1 General

The Bronkhorst High-Tech B.V. instruments are designed in such a way that they will meet user process requirements in the best possible way.

The LIQUI-FLOW L30 meters/controllers can be powered from +15 Vdc to +24 Vdc.
When providing your own power supply be sure that voltage and current rating are according to the specifications of the instrument(s) and furthermore that the source is capable of delivering enough power to the instrument(s).
Cable wire diameters should be sufficient to carry the supply current and voltage losses must be kept as low as possible. When in doubt: consult factory.
Caution: The LIQUI-FLOW L30 meters/controllers must be powered via the 8 pin circular connector. It is not possible to power the instruments via the bus connector.

Digital instruments can be operated by means of:

1. Analog interface (0...5Vdc/0...10Vdc/0...20mA/4...20mA)
2. RS232 interface (connected to COM-port by means of special cable on 38400 Baud)
3. FLOW-BUS
4. PROFIBUS-DP
5. DeviceNet
6. Modbus (special request)

Option 1 and 2 are always present on multibus instruments. An interface to any available fieldbus is optional.
Operation via analog interface, RS232 interface and an optional fieldbus can be performed at the same time.
A special parameter called “control mode” indicates to which setpoint the controller should listen: analog or digital (via fieldbus or RS232). The RS232 interface behaves like a FLOW-BUS interface.
When using more interfaces at the same time, reading can be done simultaneously without problems.
When changing a parameter value, the last value send by an interface will be valid.

Also the push-button switch and the LED’s on the back side of the instrument can be used for manual operation of some options.
The green LED will indicate in what **mode** the instrument is active.
The red LED will indicate **error/warning** situations.

3.2 Power and warm-up

Before switching on power check if all connections have been made according to the hook-up diagram which belongs to the instrument.
It is recommended to turn on power before applying pressure on the instrument and to switch off power after removing pressure.
Check fluid connections and make sure there is no leakage. If needed purge the system with a proper fluid.
For a gas instrument only purging with gases is allowed. Liquid instruments may be purged with either a gas or a liquid, whatever is needed for the purpose.
Turn on power and allow at least 30 minutes to warm up and stabilise. In cases where no electronics are involved (valves only) warming up is not needed.
During warm-up period, fluid pressure may either be on or off.

3.3 Start-up

Turn on fluid supply gently. Avoid pressure shocks, and bring the instrument gradually up to the level of the actual operating conditions. Also switch off fluid supply gently.

3.4 Operating conditions

Each instrument has been calibrated and adjusted for customer process conditions.
Controllers or valves may not operate correctly, if process conditions vary too much, because of the restriction of the orifice in the valve.

3.5 Instrument performance

3.5.1 Meters

Assuming that the transfer function of a system is an exponential shaped curve, the time constant is defined as follows:
time constant = time for the signal to reach 63.2 % of its final output value. Approx. five time constants is the time to reach the final value.

For the LIQUI-FLOW L30 meters the actual response depends on model and flow rate.

3.5.2 Controllers

The dynamic response of a controller is factory set. Standard settling-time is defined as the time to reach the setpoint (and stay) within ± 2% of the initial setpoint. The settling time depends on the properties of the flow, the system pressure and the valve type used.
The control mode is factory set in such a way that after a stepwise change in the flow, there will be little overshoot.

3.6 Manual operation

By means of manual operation of the push-button switch (#) some important actions for the instrument can be selected/started. These options are available in both analog and BUS/digital operation modes.
(See also manual operation in document number 9.17.023)

These functions are:

- Reset (instrument firmware-program reset)
- Restore factory settings (in case of unintentionally change of the settings)

for FLOW-BUS only:

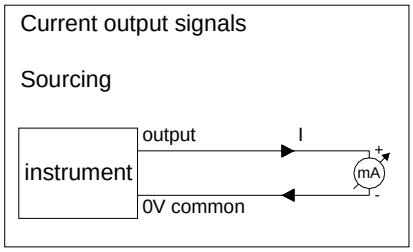
- Automatic installation to FLOW-BUS (installs instrument to free address)
- Remote installation to FLOW-BUS (instruments will be installed by E-7000 or PC-software)

3.7 Analog operation

Digital instruments can be operated with analog signals through the 8-pin circular connector.
The instruments are compatible in use with **analog** instruments on this point.
Analog operated instruments, can be hooked up using an 8-wire shielded cable, connected according to the Bronkhorst High-Tech standard.

Each electronic P. C. board is set for one of the following output (and corresponding input) signals:

Signal code	**output (sensor) signal**	**input (setpoint) signal**
A	0…5 Vdc	0…5 Vdc
B	0…10 Vdc	0…10 Vdc
F	0…20 mA (sourcing)	0…20 mA (sinking)
G	4…20 mA (sourcing)	4…20 mA (sinking)



For meters only the output signal is available.

At analog operation the following parameters are available:
- measured value
- setpoint (controllers only)
- valve voltage (controllers only)

Note:
When operating the instrument through the analog interface it is possible to connect the instrument to any supported fieldbus system (or RS232-interface with special cable) for reading/changing parameters (e.g. controller response or other fluid selection).

For FLOW-BUS versions of the instruments a readout/control module for digital instruments can be temporarily connected to the M12 Connector.

3.8 BUS / digital operation

Operation via fieldbus reduces the amount of cables to build a system of several instruments and offers more parameter values to be monitored/changed by the user.

See instruction manual: operating digital mass flow / pressure instruments for more details (document nr. 9.17.023).

Operation by means of a fieldbus adds a lot of extra features (compared to analog operation) to the instruments.
Such as:

- setpoint slope (ramp function on setpoint for smooth control)
- 8 selectable fluids
- direct reading at readout/control module or host computer
- testing and self diagnosis
- response alarm (setpoint-measure too high for too long time)
- several control/setpoint modes (e.g. purge/close valve)
- master/slave modes for ratio control (FLOW-BUS only)
- identification (serialnumber, modelnumber, device type, user tag)
- adjustable minimal and maximal alarm limits
- (batch) counter
- adjustable response time for controller when opening from zero
- adjustable response time for normal control
- adjustable response time for stable control (|setpoint-measure| < 2%)

Special software like FlowDDE, FlowPlot and FlowView can be used to control these settings.

For operation of digital instruments by means of a specific fieldbus system or RS232, see following documents (available as PDF-file):

- for FLOW-BUS document number: 9.17.024
- for PROFIBUS-DP document number: 9.17.025
- for DeviceNet document number: 9.17.026
- for RS232 document number 9.17.027
- for Modbus document number 9.17.035

Note:
Special RS232 cable has partnr. 7.03.348 and consists of a T-part with 1 male and 1 female 8DIN connector on one instrument-side and a normal female sub-D 9 connector on the side of the computer.
By means of this cable it is possible to offer RS232 communication and still be able to connect power-supply and analog interface through the (analog) 8DIN connector.
RS232 communication is only possible with a baudrate of 38.4 KBaud and can be used for either:

- Uploading new firmware by means of a special program (for trained BHT-service personnel only)
- Servicing your instrument using BHT-service programs (for trained BHT-service personnel only)
- Operating your instrument using FLOWDDE, FLOWB32.DLL or RS232-ASCII protocol (end user)

4 MAINTENANCE

4.1 General

No routine maintenance is required to be performed on the meters or controllers. In case of severe contamination it may be required to clean the valve orifice separately.

4.2 LIQUI-FLOW L30 sensor

The user cannot change the flow range of a liquid flow sensor. The sensor is an integral part of the instrument and cannot be removed from it. For occasional cleaning the instrument may be flushed with a cleaning fluid.

4.3 Controllers

All sensor types can be combined with a control valve to be operated together as a control loop. Controller systems are either available as separate units; a sensor and a control valve, or as an integrated unit.
If applicable maintenance procedures are described under “control valves”

4.4 Control valves

Control valves cannot be used for shut-off and/or on-off applications. Pressure surges, as may occur during system pressurisation or deflation must be avoided.

4.4.1 Solenoid valves

These are considered to be the directly operated control and pilot valves. They can be disassembled in the field by the user for cleaning and servicing. The parts can be cleaned with a cleaning liquid, or in an ultrasonic bath.
To disassemble the valve proceed as follows:

a) disconnect the instrument connector (not necessary with separate valve)
b) remove the hex nut on top of the valve assembly
c) lift the cover (coil) assembly
d) unscrew the flange
e) lift valve assembly carefully from the base
f) unscrew set screw for the orifice and subsequently loosen the orifice and the orifice holder
g) remove the plunger assembly

Clean parts and carefully re-assemble in reverse order. It is recommended to replace the O-rings prior to re-assembly.
After having re-assembled the control valve, it is recommended to check the control characteristics of the valve. This can best be done by using a separate variable 15 Vdc power supply source.

Proceed as follows:

- disconnect the valve leads and connect to supply source
- apply gas pressure as per working conditions
- apply power by gradually increasing voltage
- the valve should open at 7 Vdc ± 3 Vdc
- the fully opened position is reached at approx. 9 Vdc ± 1.5 Vdc.

In case the valve does not operate within the voltage levels stated, then it must be disassembled, and the orifice must be adjusted to the proper position.
Re-assemble valve and repeat procedure if required.

4.4.2 Bellows valve

These valves are suited for low pressure or vacuum applications. The user should not disassemble this model.

4.5 K_V-value calculation

This calculation method can be used to determine the K_v-value of the main orifice of a control valve.
Determine desired Δp across valve.
Δp must be at least 50% of supply pressure

Kv-value calculation

$$K_v = \frac{\Phi_m}{\rho}\sqrt{\frac{\rho}{\Delta p \cdot 1000}}$$

Units: flow - $\Phi_m(kg/h)$

density - $\rho(kg/m^3)$ at $20^\circ C$ and 1 atm.

delta p - $\Delta p(bard)$

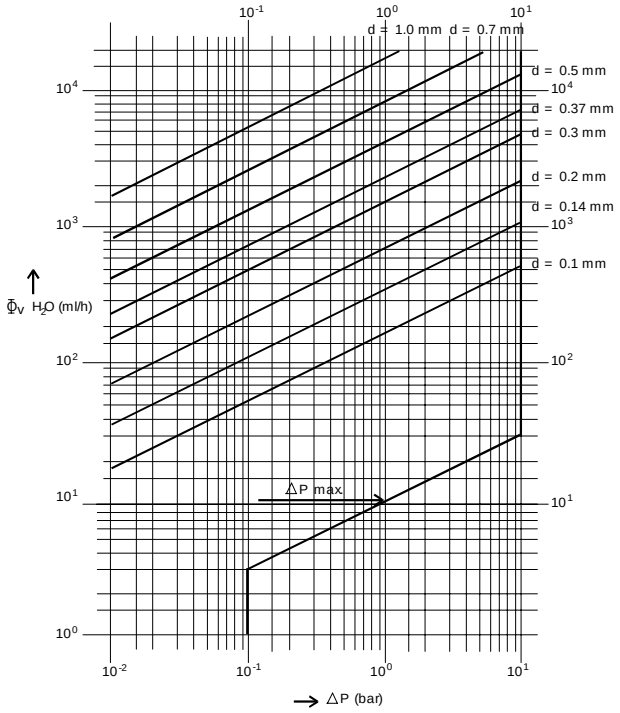
The orifice bore diameter can be determined by:

$$d = 7.6\sqrt{K_v} \qquad [mm]$$

For C2 type of valves the diameter of the orifice can be calculated as shown above or looked up in the graph below.

$$\Phi_v H_2O = \Phi_v customer \sqrt{\frac{\rho customer}{\rho H_2O}}$$

in which: Φ_v = volume flow
ρ = density



If liquids have viscosity's >15 cs (water = 1 cs), the flat orifice and plunger type control mechanism cannot be used. For measuring systems only check maximum possible viscosity with factory.

4.6 Calibration procedure

All instruments are factory calibrated. For re-calibration or re-ranging contact supplier or factory.

5 DIGITAL INSTRUMENT

See document number 9.17.023 for detailed description.

6 INTERFACE DESCRIPTION

For a description of the available interfaces see document numbers:

9.17.024 for FLOW-BUS
9.17.025 for PROFIBUS-DP
9.17.026 for DeviceNet
9.17.027 for RS232
9.17.035 for Modbus (special request)

7 TROUBLESHOOTING

7.1 General

For a correct analysis of the proper operation of a LIQUI-FLOW L30 meter or controller it is recommended to remove the unit from the process line and check it without applying fluid supply pressure. In case the unit is dirty, this can be ascertained immediately by loosening the compression type couplings and, if applicable the flange on the inlet side.
Furthermore remove the cover and check if all connectors are fixed properly. Energising or de-energising of the instrument indicates whether there is an electronic failure. When powering up the red LED is on and the green LED is flashing for a second or two. Then the instrument should go in normal operation mode. See document number 9.17.023 for detailed description of the LED indication.
After that, fluid pressure is to be applied in order to check behaviour.

7.2 Troubleshooting summary general

Symptom	Possible cause	Action
No output signal	No power supply	1a) check power supply
		1b) check cable connection
	Output stage blown-up due to long lasting shortage and/or high-voltage peaks	1c) return to factory
	Supply pressure too low, or differential pressure across meter too low	1d) increase supply pressure
	Valve blocked/contaminated	1e) connect 0 .. 15 Vdc to valve and slowly increase voltage while supply pressure is 'on'. The valve should open at 7V ± 3V; if not open, then clean parts and adjust valve (qualified personnel only)
	Screen in inlet fitting blocked	1f) clean screen
	Sensor failure	1g) return to factory
Maximum output signal	Output stage blown-up	2a) return to factory
	Sensor failure	2b) return to factory
Output signal much lower than setpoint signal or desired flow	Screen blocked/contamined	3a) clean screen
	sensor blocked/contaminated	3b) clean sensor with a gas or fluid
	Valve blocked/contaminated	3c) clean valve
	Valve internal damage (swollen seat in plunger)	3d) replace plunger assembly and adjust valve or return
	Incorrect type of gas is used and/or pressure/diff. pressure is to low	3e) try instrument on conditions for which it was designed
Flow is gradually decreasing	Valve adjustment has changed	4a) see '1e'
Oscillation	Supply pressure/diff. pressure too high	5a) lower pressure
	Controller adjustment wrong	5b) adjust controller Software like FLOWPLOT can be used to do this. Please contact the distributor for details.
	Pipeline too short between pressure regulator and LIQUI-FLOW	5c) increase length or diameter of piping upstream
	Valve sleeve or internals damaged	5d) replace damaged parts and adjust valve, see '1e' or return to factory
Small flow at zero setpoint	Valve leaks due to damaged plunger or dirt in orifice	6a) clean orifice and/or, when replacing plunger assembly, see '1e'
	Pressure too high or much too low	6b) apply correct pressure
High flow at zero setpoint	Damaged diaphragm (only applicable to valves with membrane)	7a) replace membrane seal
Disturbances in the flow	Gas in the system	8a) Purge the system
	Expansion of liquids to gasses	8b) Check properties fluid used
Calibration error	Gas in the system	9a) Purge the system
	Measure time to short	9b) Measure long enough to get a reliable measurement
	Right reference instrument	9c) The LIQUI-FLOW is a mass-flow meter/controller and should not be checked with a volume-meter.

Note: For other (more specific) problems see also troubleshooting parts in other documents.